Identification of Earth's Features from maps

Designed to meet South Carolina
Department of Education
2005 Science Academic Standards

Department of Natural Resources
South Carolina Geological Survey

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Introduction to Imagery and Topographic Maps

Standard 8-3.9: Identify and illustrate geologic features of South Carolina and other regions of the world through imagery (including aerial photography and satellite imagery) and topographic maps

Introduction

- **Geologic features on Earth can be identified through use of aerial photographs, satellite imagery and topographic maps.**
  - **Imagery Maps:**
    - Precise images using sensors and cameras can be gathered by highflying aircraft and satellites orbiting Earth.
    - Computer models translate the data into images and scientists can identify features on the Earth's surface through colors and shapes that features make on the image.
  - **Topographic Maps:**
    - These maps are a 'plan-view' of the earth's surface and have been used for more than hundred years. Topographic maps are a 2-dimensional representation of the elevation and topography, or relief, on the earth.
    - They also give locations or roads, buildings, swamps and other natural and man-made structures by using standardized symbols.
    - Understanding the scale of a map, the symbols used and contour intervals and lines is important. The scale of a map is the relationship between a distance on a map and the corresponding distance on the earth's surface
    - Cross-sectional profiles can be easily made using a topographic map, which is helpful when determining the slope of the area.

Types of Imagery

- **Satellite Images:** Most common method currently for identifying land features. Black & white, infrared black & white, natural color, infrared color, and various combinations exist in satellite imagery. Colors recorded by color infrared film are not true colors, but false colors. This is because they cut out all or part of the visible spectrum. In false colors, green plants are red and clear water is black.

- **Electronic scanning images:** This method records selected parts of the electromagnetic spectrum. A common example is SLAR (side looking airborne radar), where a radar beam is sent to the ground at a perpendicular angle, which then reflects off the surface, and is recorded by a scanner on the aircraft.

- **Aerial Photograph images:** These photos have been available since the early 1930's, though this method has largely been replaced by satellite imagery. Most photographs were taken by a camera shooting straight down (vertical photographs) from airplanes and because they have low distortion, they were useful for extracting data. Oblique aerial photos are good for illustrations, but are distorted. Typically, one views a set of overlapping aerial photographs with a stereoscope to see it in 3-dimension. Aerial photography was first practiced by the French photographer and balloonist Nadar in 1858 over Paris, France.

Honolulu, HI. USGS image

SLAR of Puerto Rico, USGS image

Football stadium, NY. USGS image.

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Using imagery to show changes on Earth's surface

- The most valuable imagery for geologists was gathered by the LANDSAT satellites launched from 1972 to 1984. All carried multispectral scanners capable of scanning 185-km wide paths in 4 separate wavelength bands corresponding to green, red, and 2 reflected infrared bands.
- False colors are obtained by projecting the four wavelength bands through filters and combining them to form a false-color composite image.
- Geologic and geographic features can be recognized as well natural events such as floods and fires.

Greece before and after fires of 2007 (NASA image).

Notice the red areas in the photo on the right indicating soil exposure where there was once vegetation.

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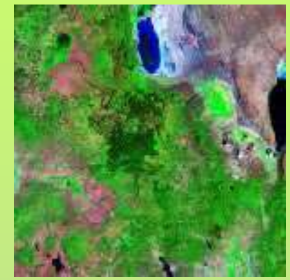
Images from satellites can provide us with changes of the land surface over time. For example, the Eyjabakkojokull is an outlet glacier in Iceland (photo right). The true-color Landsat 7 image to the right shows how much the glacier terminus has retreated in 18 years. The image was taken in 2000, where one can see even more retreat since 1991 (NASA image).

Entire cities can be monitored for wide spread changes. There were noticeable land-mark changes to the New York City landscape after September 11, 2001. To the left is an image of Baghdad, where land surface changes have occurred over recent years (NASA image).

South Carolina is an interesting state because there are a variety of terrains that can be easily identified on many types of maps including mountains and streams of the Piedmont Region and Carolina Bays and swamplands of the Coastal Region.

In addition, **1. coastal features, 2. forested areas, 3. farmlands, 4. tributaries, and 5. lakes** can be observed on imagery maps.

Satellite image of South Carolina. All images used with permission of geology.com



Forest (lush green)

Farmland (red/green patchwork)

Swampland and estuaries

Lakes (light blue to black depending on sediment load)

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- **<u>Carolina Bays</u>** are an interesting surface feature located along the Atlantic seaboard. They are elliptical depressions numbering approximately 500,000 clustered in groups from Florida to New Jersey and are usually oriented NW-SE.

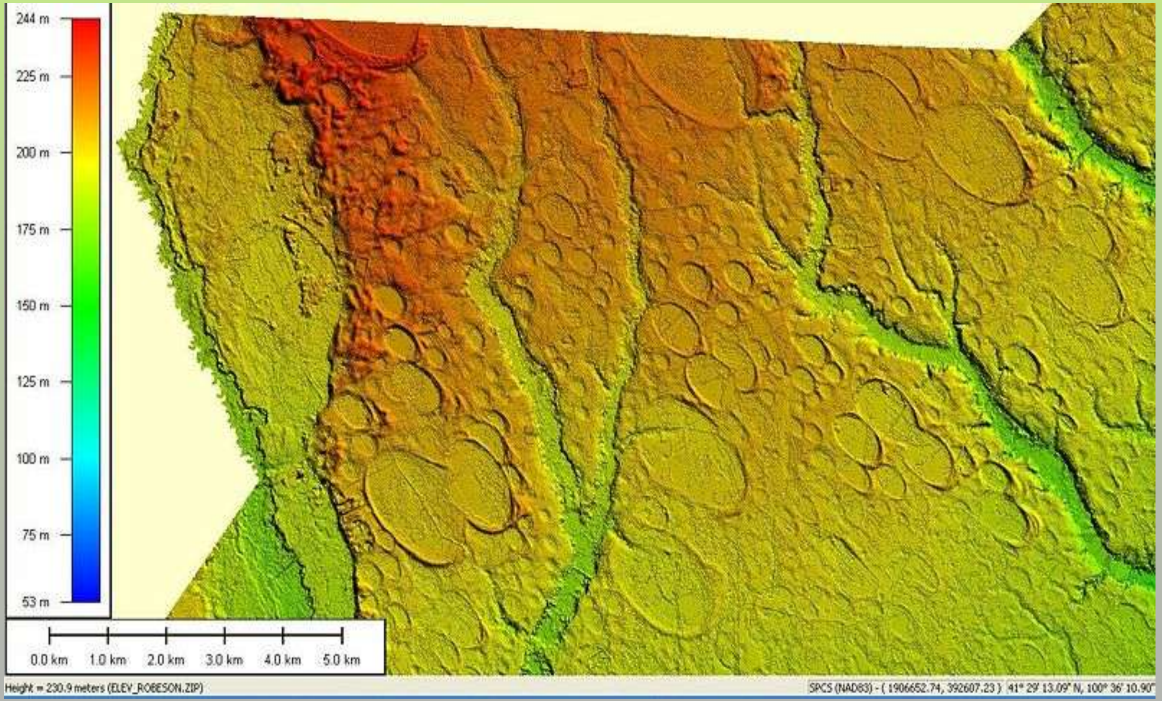
- Most of these bays are marshy wetlands. Some of the larger ones are lakes and they vary in size from one to several thousand acres.

A cluster several of bays filled with vegetation *(wikipedia image, public domain)*

- Radiocarbon and palynology (pollen) dating techniques indicate that the bays are of Pleistocene age.

- Bays can be seen clearly on topographic and imagery maps.

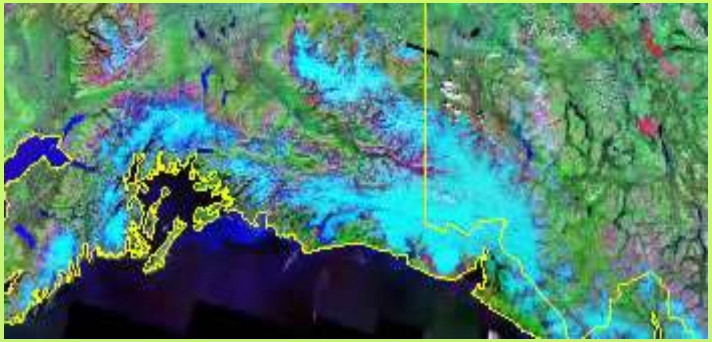
- No one theory for origin has been confirmed, and theories include sea currents, upwelling of groundwater, and climate change. Scientists have found that the orientation is consistent with wind patterns during the last glaciation.



Elliptical Carolina bays of N.C. clearly seen on digital elevation image *(wikipedia image, public domain)*

Other land surface features of the world can be seen by studying imagery

Folded mountains of the Appalachians, Penn. *(geology.com image)*



Alaskan glaciers, usually as light blue *(geology.com image)*

Drumlin field, Wayne County N.Y. (USGS image)

Volcanoes, Wash. *(geology.com image)*

Finger Lakes, N.Y. (*geology.com image)*

Mt. St. Helens (eruption 1980) *(NASA image)*

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False-color Landsat image of the Great Salt Lake

Mini-exercise

1. Where is healthy vegetation most abundant? To the east indicated by abundance of red.
2. Why is the vegetation pattern 'splotchy' near the lake? Land clearing.
3. What is the white line trending northwest? Cloud cover
4. Remember that this lake was bigger in the past. What are the two white patches in the west and southwest of the Lake? Salt deposits
5. What is the reason for the sharp line separating the light blue half from the dark blue half of the lake? A man-made dam/causeway
6. Explain the colors? Lighter blue colored water has more sediment and may be shallower.

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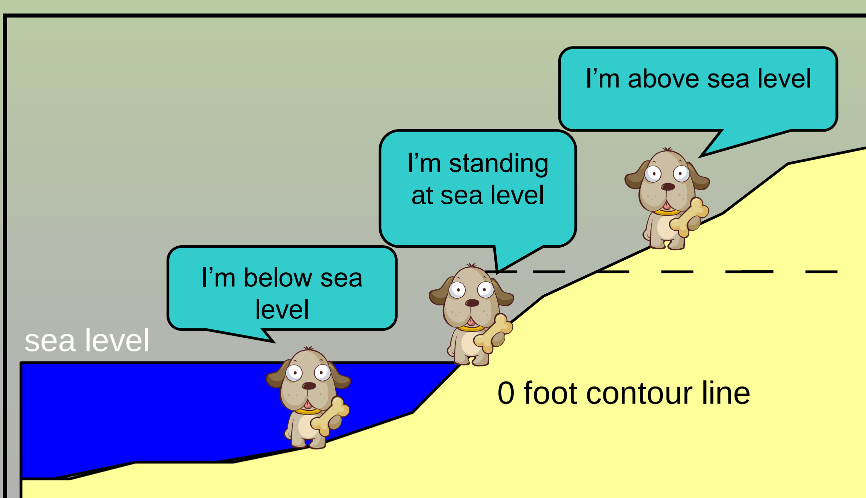
Topographic Maps

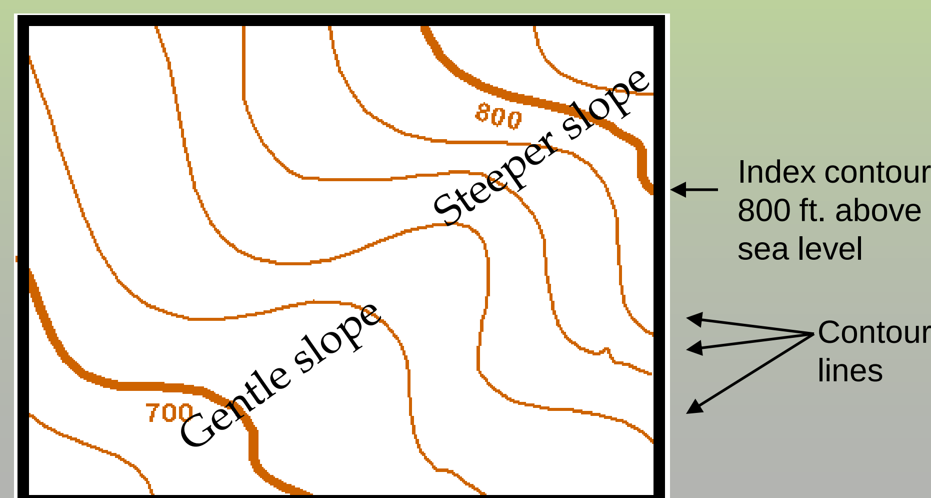
- Topographic maps show elevations, which is the height of the land above (or below) sea level. Sea level is always ZERO and is always the reference point. You can download topographic maps of South Carolina from this website: http://www.dnr.sc.gov/gis.html

- Elevations are shown by **contour lines**. Contour lines follow the contours, or the topography, of the land and connects points with the same elevation. If a point falls on a contour line, that point is the same elevation as the contour line. If it falls between two contour lines, it is some value between the two elevations.

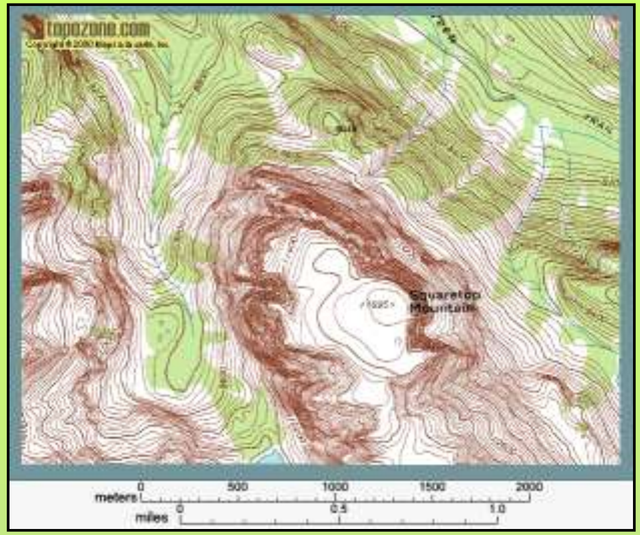
- The distance between contour lines shows the steepness of the slope. Slope indicates the "steepness" of topography and is found by dividing the change in elevation between two points over the horizontal distance between the two points, or "rise over run".
    - Contour lines close together = steep slope
    - Contour lines far apart = gentle slope

- The contour interval (CI) is the difference in elevation between two contour lines and is always indicated at the bottom of the map. An index contour line has the elevation written on it and is usually darker than all other contour lines.



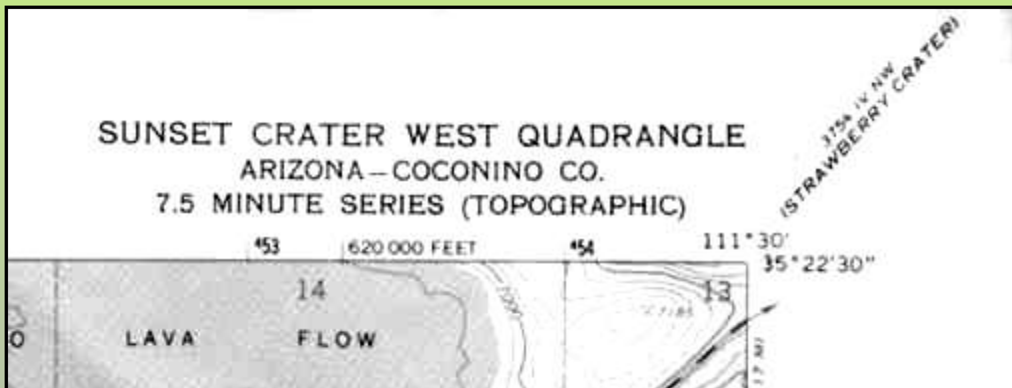


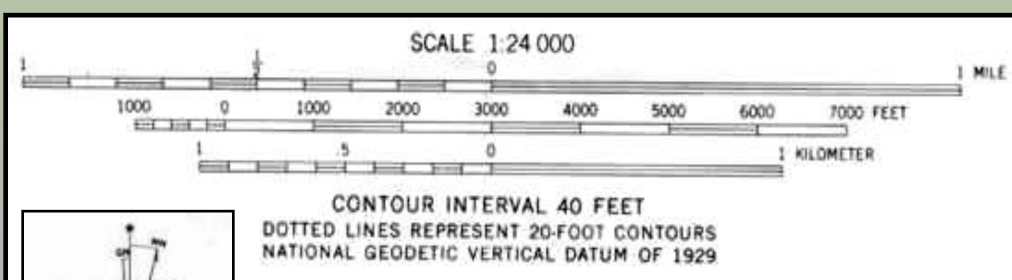
Contour Interval: 20 ft.

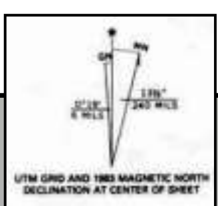


Topographic maps are a plan view of the land surface. To the left is a photo of a cross-section view of Squaretop Mountain, Wyoming and the topographic map to the right is a plan view of the same mountain. The brown contour lines become very close together indicating the steep mountain sides.

http://raider.muc.edu/~mcnaugma/Topographic%20Maps/topomapindexpage.htm







Topographic maps are made by the United State Geological Survey and there are a few key points to understanding how to read a map.

1. Quadrangle name (top right corner)
2. Corner names indicate the quadrangle name of the adjacent area
3. Latitude and Longitude on edges
4. Contour interval (bottom)
5. Map scale (bottom)
6. Magnetic declination (bottom). This is the slight difference between magnetic north and true north.

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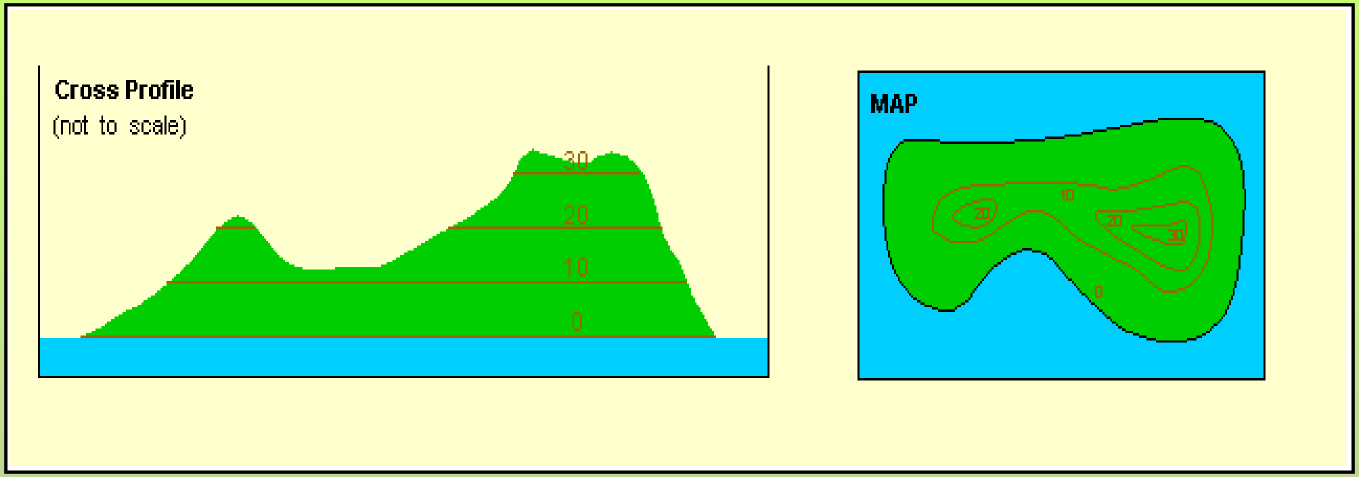
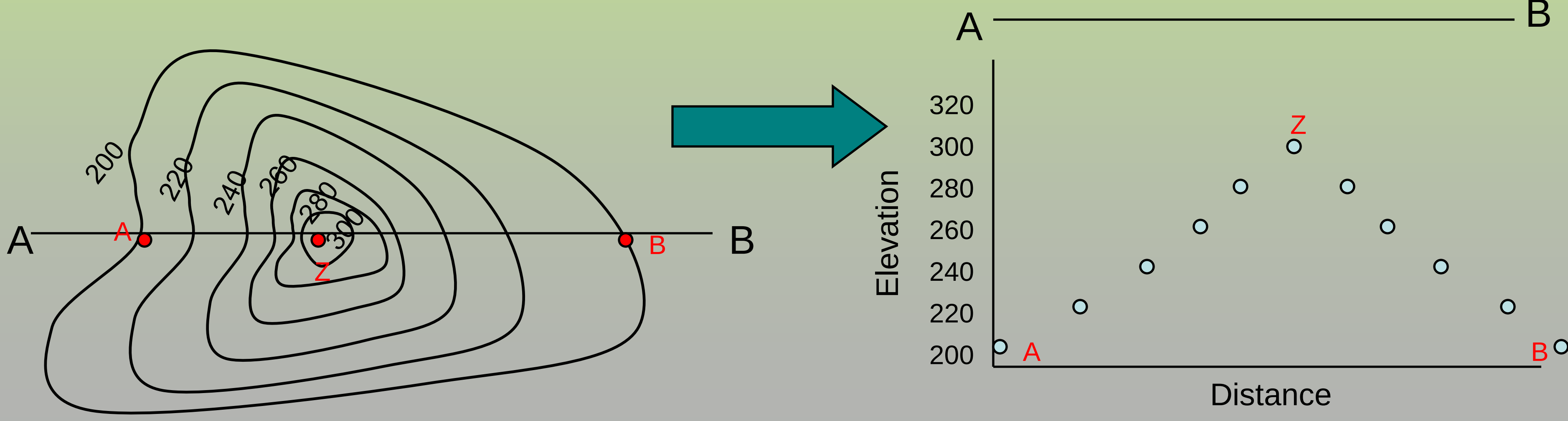
- Geological features can be identified on a topographic map by the patterns of contour lines and intervals as well as special symbols. Features can also be described by a 3-D profile.
- Making a topographic profile is a very simple and useful skill. See example below.



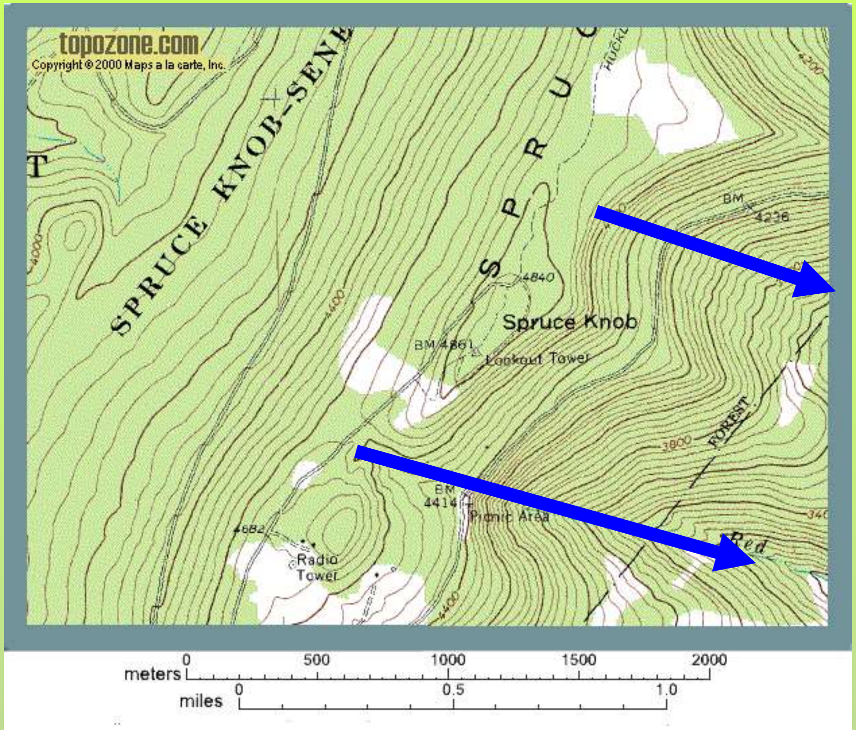
The left figure is a cross-section of an island with elevation lines. The right figure is a plan view of that same island with contour lines. Below is an example of how to draw a profile from a topographic map.

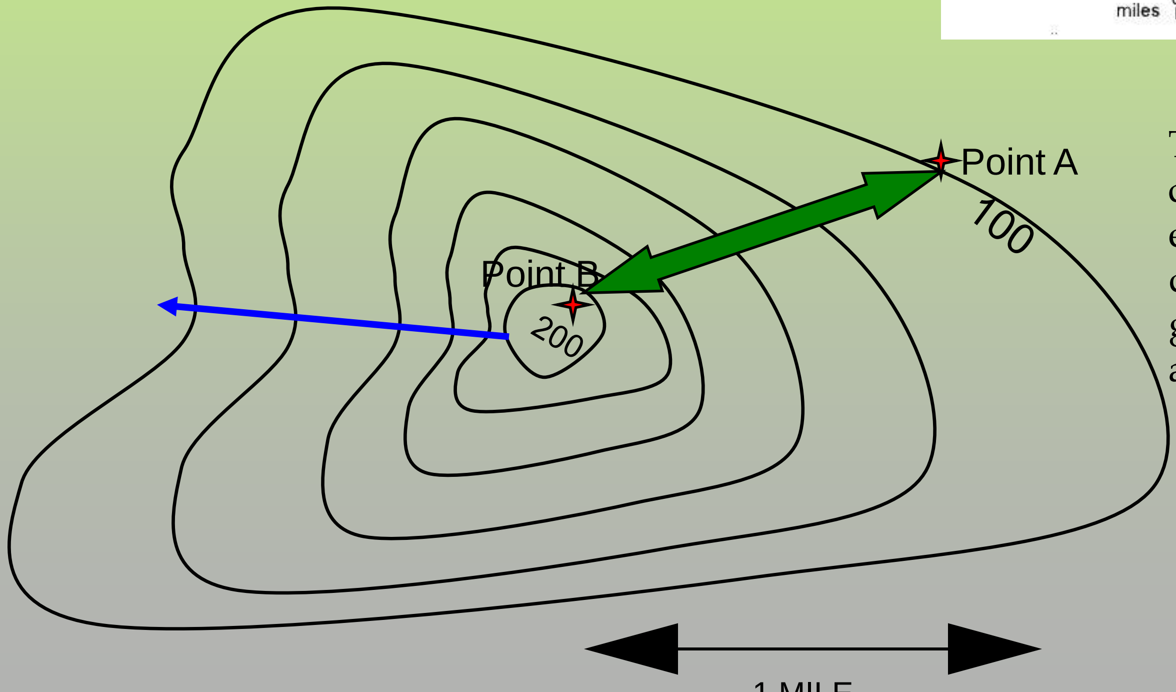


▪ Features indicated on a topographic map include rivers, marshes, lakes, gravel pits, roads, buildings, domes, and basins (hachures).

▪ A series of closed, looped contour lines shows a hill or a depression. A depression is marked by little tick marks on the inside of the closure.

▪ A V-shape indicates a valley and usually a river is indicated by a blue line. The V will always point upstream.





The gradient, or slope, can be calculated by dividing the change in elevation between two points by the distance between the two points. This gives you a vertical change relative to a path distance.

Elevation:

Point B – Point A = 200 – 100 = 100 ft.

Distance:

1 mile

So the gradient is 100 ft/mile

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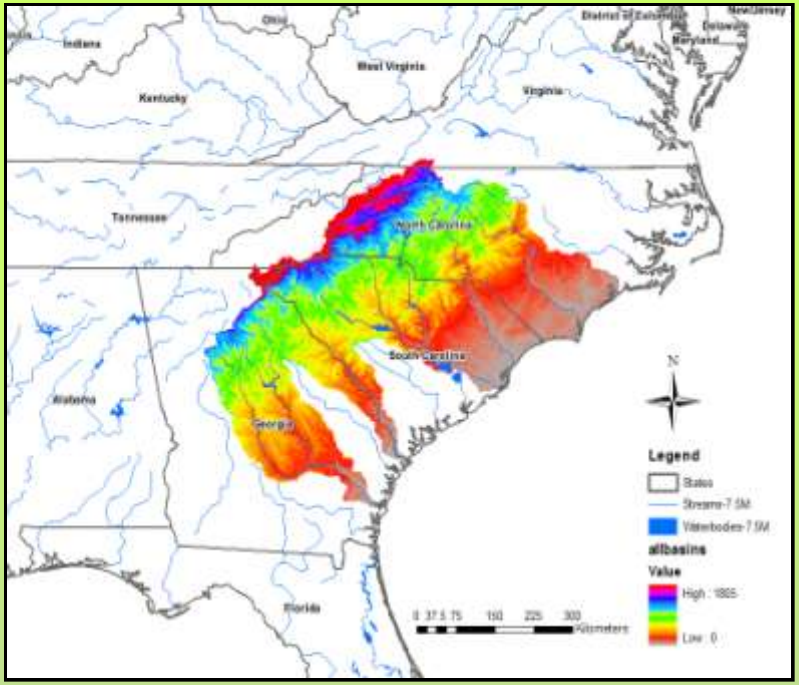
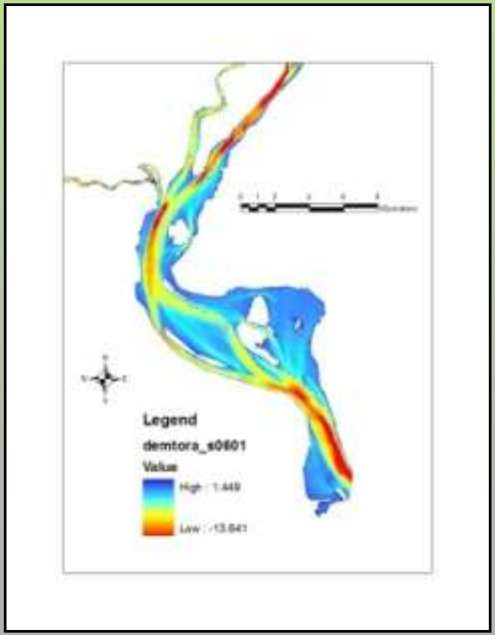
Digital Elevation Models

- Digital elevation models (DEMs), less commonly called digital terrain models (DTMs), are 2-D grids where each grid element (cell) is assigned an average elevation value. **They are similar to topographic maps in that they are maps of elevation.**
- Digital elevation models may be developed a number of ways, but they are frequently obtained by remote sensing rather than by direct survey. Originally, DEMs were produced by extracting elevation data from existing topographic maps and then digitizing the elevations or by using photogrammetric stereomodels, old aerial photographs, or satellite images.
- USGS 7.5-minute DEMs, the most common type of DEM available, is a 30-meter DEM, meaning each cell element within the DEM corresponds to a square region 30 meters on a side, such that it is termed "30-meter resolution."
- DEMs are available to the public and are easily obtainable from the USGS National Elevation Dataset web page (http://seamless.usgs.gov/website/Seamless/) and the South Carolina Department of Natural Resources GIS web page (http://www.dnr.sc.gov/gis.html).



Digital elevation models of 5 southeastern watersheds.



Underwater elevation of Winyah Bay, called a bathymetric model

Pictometry

- Pictometry International Corporation of New York is the provider of a patented information system that captures georeferenced, digital aerial oblique and orthogonal images, which extends the benefits of traditional straight-down photography providing a unique perspective view of a locality.

- With this new enhanced means of imagery, it is now possible to: ***http://www.blompictometry.com/intro.html***

  - See sides of a building, structure or feature, exposing blind spots, exits and entrances previously impossible to locate on straight-down photography.

  - Provide the ability to measure the height, length, and area of features directly from photography. Measurements can be made between real world objects rather than their graphic representation in a 3D model.

  - Improve the identification of hard to see assets and facilities (e.g. lamp-posts, telegraph poles, etc) which can be difficult to distinguish on traditional ortho photography.

  - View GIS data in 3D by draping it on oblique imagery, extending the traditional and more familiar 2D view afforded by most GIS applications.

"Acquired from multiple cameras, Pictometry® brings a new perspective to oblique aerial photography available for stand alone use or integrated within GIS. Geo-referenced images provide the user with the ability to orientate, measure, see and plan to a degree not previously possible with traditional ortho photography and combined with existing vector datasets users can leverage their geographic information still further."
http://www.blompictometry.com/intro.html

Pictometry image of a port in Spain.
http://www.blompictometry.com/intro.html

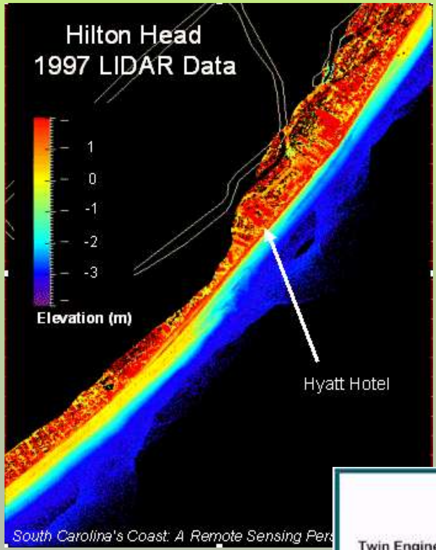
LIDAR

- **LIDAR** (**Li**ght **D**etection **a**nd **R**anging) is an optical remote sensing technology that measures properties of scattered light to find range and other information of a distant target. It uses laser pulses to determine the distance to an object. Like similar radar technology, which uses radio waves instead of light, the range to an object is determined by measuring the time delay between transmission of a pulse and detection of the reflected signal.

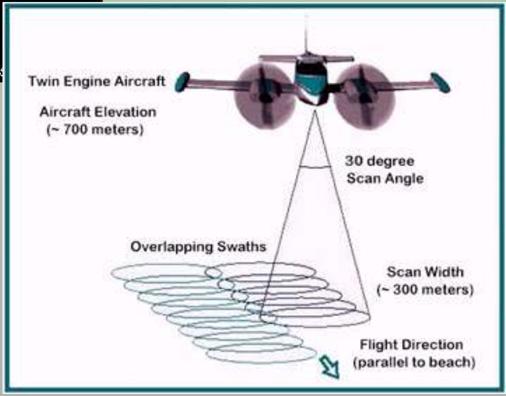
- Lidar is highly sensitive to aerosols and cloud particles and has many applications in atmospheric research and meteorology, as well as geology, geography, geomorphology, remote sensing, and archaeology.

- The LIDAR instruments only collect elevation data. To make these data spatially relevant, the positions of the data points must be known. A high-precision global positioning system (GPS) antenna is mounted on the aircraft. As the LIDAR sensor collects data points, the location of the plane is simultaneously recorded by the GPS sensor. After the flight, the data are downloaded and processed using specially designed computer software. The end product is accurate, geographically registered longitude, latitude, and elevation (x,y,z) positions for every data point. These "x,y,z" data points allow the generation of a digital elevation model (DEM) of the ground surface.

- LIDAR is commonly used along the coastlines to measure coastline retreat.



LIDAR elevation data, NOAA



Collection of LIDAR from aircraft, NOAA

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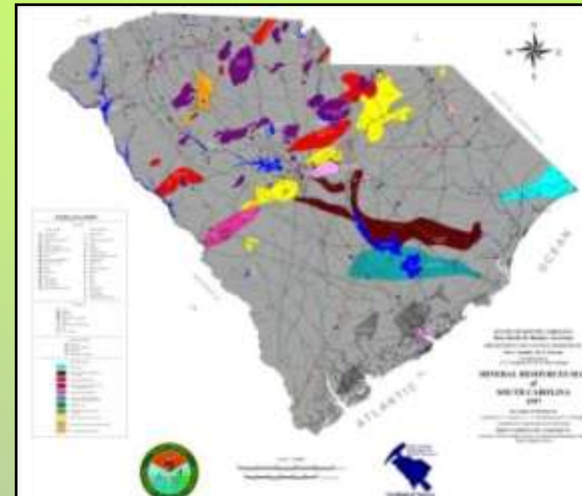
Other types of Maps

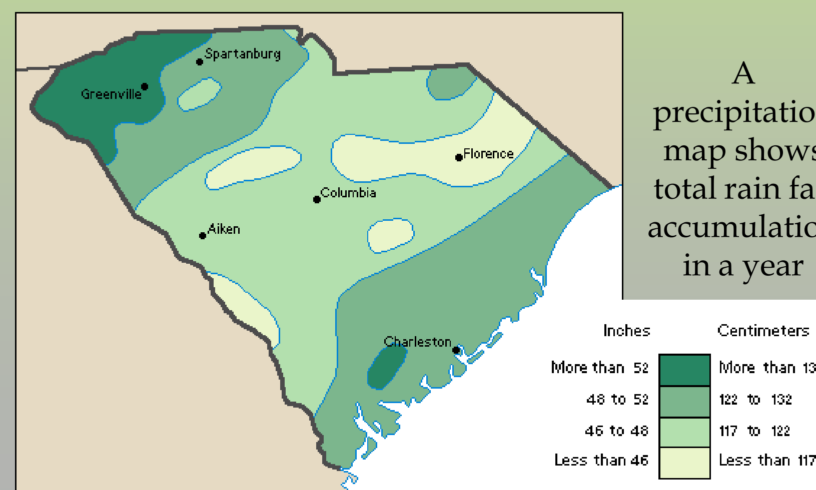
- There are many other types of maps that can be used to identify geologic features, agricultural practices, climate, population density and many other dynamics of the state of South Carolina.

Geologic maps show different types of rock, or lithology, through colors



A natural resources map identifies areas of interest for valuable minerals throughout the state.

An earthquake hazards map shows where past earthquakes have occurred and how strong they were by using the intensity (Mercalli) scale



A precipitation map shows total rain fall accumulation in a year

South Carolina Science Academic Standards: Grade 8

Standard 8-3: The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure.

Indicator:

8-3.9: Identify and illustrate geologic features of South Carolina and other regions of the world through imagery (including aerial photography and satellite imagery) and topographic maps